USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Project ID: 2002IL7G

Title: Development and Validation of a 3D Coupled Hydrologic-Biogeochemical Model for Evaluation of the Impact of Water-Table Management on Nitrate Loads from Tile-Drained Agricultural Fields

Project Type: Research

Focus Categories: Nitrate Contamination, Non Point Pollution, Solute Transport

Keywords: Best Management Practices, Tile-Drained Fields, Conjunctive Models, Biogeochemical Models, Drainmod-N

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Abstract

Elevated nitrate levels in the water resources of the Midwestern US are a major regional water quality issue. The most direct impact of nitrates is on surface and subsurface drinking-water supplies, causing drinking water MCLs to be exceeded in numerous locales. Although nitrogen contributions from atmospheric deposition and point discharges are important sources within the Mississippi River Basin, agriculture has been implicated as the largest single contributor to the problem. Widespread use of tile drainage in Illinois and surrounding states exacerbates the problem, since the tiles are a short circuit for nitrate to directly enter surface waters and prevent longer-term transport of nitrate through reduced groundwater systems where there is a high likelihood for denitrification. Ultimately, nitrate-N transported via the Mississippi River to the Gulf of Mexico appears to be a major cause of eutrophication and hypoxic (low oxygen) conditions in estuaries and near-shore coastal environments. One of the most promising approaches to minimizing nitrate export to rivers draining agricultural watersheds is the use of water table management, or controlled drainage. The Illinois District of the USGS is conducting a field pilot study of the benefits of controlled drainage at an active farm in east-central Illinois. Two adjacent 40- acre plots, one with tile management and the other without, have been instrumented for collecting a variety of data. Modeling is required to fully interpret the field data and to extend the results to other farm conditions. Thus, a portion of the USGS project includes modeling studies with DRAINMOD-N, a widely applied quasi-2- dimensional model. However, because raising the water table of a farm field may increase the amount of runoff and change its subsurface interactions with the larger-scale groundwater flow field, we hypothesize that a fully 3-dimensional model is required to properly quantify the hydrologic and nitrogen budgets of the study site. Our proposed model will simulate both surface runoff/runon and subsurface flow between the adjacent managed/conventional plots (and adjacent fields), processes which can only be

represented very approximately in DRAINMOD, if at all. The improved hydrology of the model will also allow us to improve our analysis of the N budgets of the two plots, since it accounts more accurately for nitrate exchange between adjacent plots by the above hydrologic paths and will better simulate differences in denitrification in surface ponds/puddles and in the subsurface due to increases in water and solute residence times.

We propose development of a physically-based, 3-dimensional model that couples surface and subsurface flow with a biogeochemical model for nitrogen fate. The model will be calibrated and validated using the field data collected by the USGS and other existing data from fields in central Illinois. The analysis of hydrologic and N budgets for the USGS site will be compared and the relative predictive power of the 3D model will be benchmarked against DRAINMOD. The model will be a powerful tool for understanding the processes controlling nitrate transport at the field scale, and will invaluable for quantitative assessment of a variety of best management practices aimed at minimizing nitrate export from tile-drained fields.